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IS 4431 (1978): Carbon and carbon manganese free cutting steels [MTD 16: Alloy Steels and Forgings]



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Bhartrhari—Nitiśatakam

“Knowledge is such a treasure which cannot be stolen”



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IS : 4431 - 1978  
(Reaffirmed 1998)

*Indian Standard*

SPECIFICATION FOR  
CARBON AND CARBON-MANGANESE  
FREE-CUTTING STEEL

*( First Revision )*

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BUREAU OF INDIAN STANDARDS  
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG  
NEW DELHI 110002

# *Indian Standard*

## SPECIFICATION FOR CARBON AND CARBON-MANGANESE FREE-CUTTING STEEL

### ( *First Revision* )

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( *Continued on page 2* )

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*Indian Standard*  
SPECIFICATION FOR  
CARBON AND CARBON-MANGANESE  
FREE-CUTTING STEEL  
( *First Revision* )

0. F O R E W O R D

**0.1** This Indian Standard ( First Revision ) was adopted by the Indian Standards Institution on 7 December 1978, after the draft finalized by the Alloy Steels and Special Steels Sectional Committee had been approved by the Structural and Metals Division Council.

**0.2** This standard was first published in 1967. As a result of the experience gained in the production and use of free-cutting steels, the concerned Sectional Committee has decided to undertake its revision.

**0.3** The major modifications made in the revision relate to the following:

- a) Modification in the carbon content of grade 13S<sup>25</sup> ( new designation 11C10S25 )
- b) Change in the mechanical properties of grades 40S<sup>18</sup> ( new designation 40C10S18 ) and 40 Mn2S<sup>12</sup> ( new designation 40C15S12 )
- c) Modification in the limits for residual elements keeping in view the international practice.

**0.4** Free-cutting steels are characterized by properties of good machinability and satisfactory chip break up. These properties are mainly achieved by the addition of sulphur. Other additions, like lead and selenium, are also made either jointly with sulphur or separately to improve the machinability. Machinability is also improved by cold-working, but it deteriorates as the carbon content and the level of deoxidation of the steel increase.

**0.5** Steels 10C8S10 and 14C14S14 are suitable for case-hardening and have been included in IS : 4432-1967\*.

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\*Specification for case hardening steels.

**0.5.1** Steels 40C10S18 and 40C15S12 are suitable for hardening and tempering and have been included in IS : 5517-1969\*. Steel 40C15S12 has also been included in IS : 3930-1966† as it is suitable for flame and induction hardening.

**0.6** For the benefit of the purchaser, particulars to be specified by the purchaser while ordering for steels have been included in Appendix A.

**0.7** This standard contains clauses 4.1, 5.1, 5.2, 6.3, 9.1 and 10.1.1, which call for agreement between the supplier and the purchaser and permit the purchaser to use his option for selection to suit his requirements.

**0.8** For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test, shall be rounded off in accordance with IS : 2-1960‡. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

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## **1. SCOPE**

**1.1** This standard covers the requirements for wrought carbon and carbon-manganese free-cutting steels supplied in the form of blooms, billets and bars.

## **2. TERMINOLOGY**

**2.1** For the purpose of this standard, the definitions given in relevant parts of IS : 1956§ shall apply.

## **3. SUPPLY OF MATERIAL**

**3.1** General requirements relating to the supply of carbon and carbon-manganese free-cutting steels shall conform to IS : 1387-1967||.

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\*Specification for steels for hardening and tempering.

†Specification for flame and induction hardening steels.

‡Rules for rounding off numerical values (*revised*).

§Glossary of terms relating to iron and steel ( Parts I to VIII ).

||General requirements for the supply of metallurgical materials (*first revision*).

**3.2** Steels covered in this standard shall be ordered and delivered on any one of the following basis:

<i>Requirements</i>	<i>Types of Conditions of Delivery</i>				
	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>
Chemical composition	X	X	X	X	X
Mechanical properties in hot-worked or normalized condition	—	X	—	—	—
Mechanical properties in quenched and tempered condition for the ruling section	—	—	X	—	—
Mechanical properties in the cold-worked condition	—	—	—	X	—
Mechanical properties ( core properties ) in the refined and quenched condition for case-hardening steels	—	—	—	—	X

#### **4. MANUFACTURE**

**4.1** Unless otherwise agreed to in the order, the process used in making the steel and the product shall be left to the discretion of the manufacturer, but the steel shall either be semi-killed or killed. When so desired, the purchaser shall be informed of the steel making process.

**4.2** Sufficient reductions and discards shall be made from each ingot to ensure freedom from piping, segregation and other harmful defects.

#### **5. FREEDOM FROM DEFECTS**

**5.1** The material shall be free from internal and surface defects and the method of evaluating the internal defects shall be mutually agreed between the purchaser and the manufacturer at the time of enquiry and order.

**5.2** Unless agreed otherwise, the material may be conditioned to remove the surface defects. The process and depth of conditioning shall be subject to agreement between the purchaser and the manufacturer.

**5.3** Minor defects, such as slight porosity, pitting, foliation and scoring due to drawing, turning or polishing, shall be permitted.

**5.4** Sulphide inclusions and segregation bands which are bound up with the nature of free-cutting steels shall not be deemed as defects in the material.

## **6. CHEMICAL COMPOSITION**

**6.1** The ladle analysis of steels shall conform to requirements given in Table 1.

**6.2 Check Analysis** — The check analysis shall be carried out on the finished product. The permissible variation in the case of such check analysis from the limits specified in Table 1 shall be as given in Table 2.

**6.3** The following elements, which are not specified in Table 1, shall not be added to the steels except where agreed to, other than for the purpose of finishing the heat, and shall not exceed the following limits:

<i>Constituent</i>	<i>Percent, Max</i>
Chromium	0.25
Nickel	0.25
Molybdenum	0.05
Copper	0.35
Vanadium	0.05

**6.3.1** The total of the above residual elements shall not exceed 0.80 percent.

## **7. HEAT TREATMENT**

**7.1** Recommended heat treatment procedure for steels is given in Appendix B.

## **8. MECHANICAL PROPERTIES**

**8.1** Steels, when supplied in the hot-rolled, normalized, cold-drawn or in the hardened and tempered condition, shall conform to the mechanical properties specified in Tables 3, 4 and 5.

**8.1.1** The properties given in Tables 3, 4 and 5 shall be applicable to test pieces taken on rounds in the direction of fibre, the axis of which corresponds to Fig. 1. For rectangular sections, the ranges for equivalent sections shall be as given in Fig. 2.

**8.1.2** The tensile test shall be done in accordance with IS: 1608-1972\*.

**8.1.3** The izod impact test shall be conducted in accordance with IS : 1598-1960†.

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\*Method for tensile testing of steel products (*first revision*).

†Method for izod impact test for steel.

TABLE 1 CHEMICAL COMPOSITION OF FREE-CUTTING STEELS

( *Clauses 6.1, 6.2 and 6.3* )

STEEL DESIGN- ATION  CONSTITUENT, PERCENT	REFERENCE TO METHODS OF CHEMICAL ANALYSIS						
	10C8S10	14C14S14	25C12S14	40C10S18	11C10S25	40C15S12	
Carbon	0.15 <i>Max</i>	0 10 0 18	0 20-0 30	0 35-0 45	0 08-0 15	0 35-0.45	IS 228 ( Part I ) 1972*
Silicon	0 05-0 30	0 05-0 30	0 25 <i>Max</i>	0 25	0 10	0 25	IS 228 ( Part VIII )-1975*
Manganese	0 60-0 90	1 20-1 50	1 00-1 50	0 80-1.20	0 80-1.20	1 30-1 70	IS 228 ( Part II )-1972*
Sulphur	0 08 0 13	0 10-0 18	0 10-0 18	0 14-0 22	0 20-0 30	0.08-0 15	IS 228 ( Part IX )-1975*
Phosphorus	0 060 <i>Max</i>	0 060 <i>Max</i>	0 060 <i>Max</i>	0 060 <i>Max</i>	0 060 <i>Max</i>	0 60 <i>Max</i>	IS 228 ( Part III )-1972*

NOTE 1 — The steel can be supplied in killed or semi-killed type. In case of killed steel, minimum silicon level should be 0 10 percent.

NOTE 2 — When required lead and other elements are specified as added elements

\*Methods of chemical analysis of steels Part I Determination of carbon by volumetric method ( for carbon  $\geq 0 1$  percent ) ( *second revision* ).

Part VIII Determination of silicon by gravimetric method ( for silicon  $\geq 0 1$  percent ) ( *second revision* ).

Part II Determination of manganese in plain carbon and low alloy steels ( Arsenic method ) ( *second revision* )

Part IX Determination of sulphur in plain carbon steels by evolution method ( *second revision* ).

Part III Determination of phosphorus ( Alkalimetric method ) ( *second revision* )

NOTE 1 — The steel can be supplied in killed or semi-killed type. In case of killed steel, minimum silicon level should be 0.10 percent.

NOTE 2 — When required lead and other elements are specified as added elements

\* Methods of chemical analysis of steels Part I Determination of carbon by volumetric method ( for carbon  $\geq 0.1$  percent ) ( *second revision* ).

Part VIII Determination of silicon by gravimetric method ( for silicon  $\geq 0.1$  percent ) ( *second revision* ).

Part II Determination of manganese in plain carbon and low alloy steels ( Arsenitic method ) ( *second revision* )

Part IX Determination of sulphur in plain carbon steels by evolution method ( *second revision* ).

Part III Determination of phosphorus ( Alkalimetric method ) ( *second revision* )

**TABLE 2 PERMISSIBLE VARIATION IN CHECK ANALYSIS**

( Clause 6.2 )

ELEMENT	PERMISSIBLE CONTENT IN CAST ANALYSIS	PERMISSIBLE DEVIATION OF PRODUCT ANALYSIS
(1)	(2)	(3)
Carbon	$< 0.34$ $> 0.34$	$\pm 0.02$ $\pm 0.03$
Silicon	$\leq 0.10$ $\leq 0.10-0.30$	$+ 0$ $\pm 0.03$
Manganese	$\leq 0.90$ $> 0.90$	$\pm 0.04$ $\pm 0.06$
Phosphorus	$\leq 0.06$	$+ 0.008$
Sulphur	$\leq 0.30$	$\pm 0.03$

NOTE —  $\pm$  means that in one cast the deviation may occur over the upper value or under the lower value of the specified range in Table 1 but not both at the same time.

**TABLE 3 SPECIFIED TENSILE LIMITS FOR BARS AND BILLETS IN THE HOT-ROLLED OR NORMALIZED CONDITIONS**

( Clauses 8.1 and 8.1.1 )

STEEL DESIGNATION	TENSILE STRENGTH	ELONGATION, Min ON GAUGE LENGTH $5.65\sqrt{A}$
(1)	(2)	(3)
	N/mm <sup>2</sup>	Percent
10C8S10	365-480	24
14C14S14	430-530	22
25C12S14	490-590	20
40C10S18	540-795	17
11C10S25	365-480	22
40C15S12	640-830	15

NOTE — Minimum values for yield stress may be required in certain specifications and in such cases, a minimum yield stress of 55 percent of the minimum tensile strength should be satisfactory.

## 9. DIMENSIONAL TOLERANCES

**9.1** The dimensional tolerances for rolled steel products shall conform to either grade 1 or grade 2 of IS : 3739-1972\* subject to agreement between the manufacturer and the purchaser.

**9.2** For forged steel products the tolerances shall conform to IS : 3469 ( Parts I to III )-1974†.

## 10. SAMPLING

**10.1 Sampling for Chemical Analysis** — The ladle analysis shall be supplied by the manufacturer. If the product analysis is required by the purchaser, at least one sample product shall be taken from each cast.

**10.1.1** The selection of samples for product analysis shall be carried out as agreed between the purchaser and the manufacturer.

**10.2 Sampling for Mechanical Tests** — For the purpose of mechanical tests, samples shall be selected from the finished material as follows:

<i>Condition</i>	<i>Number of Samples</i>
Hot-worked normalized	One for every 20 tonnes or part thereof with a minimum of one per cast
Heat-treated	One from each size grouping from each heat-treatment batch. If continuously heat treated, one for every 25 tonnes or part thereof with a minimum of one per cast
Cold-worked	One for every five tonnes or part thereof but at least one per cast

**10.2.1** Test pieces for mechanical properties shall be taken in the longitudinal direction of the product in accordance with Fig. 1.

## 11. RETESTS

**11.1 Retest for Product Analysis** — If the results of the product analysis do not meet the composition requirements given in Table 1 and 2, unless otherwise agreed between the purchaser and the manufacturer, two new samples shall be taken on different pieces from the same cast. Should the two analyses satisfy the requirements, the lot represented shall be accepted. Should either of the tests fail, the material shall be taken as not complying with this standard.

\*Dimensional tolerances for carbon and alloy constructional steel products.

†Tolerances for closed die steel forgings (*first revision* ).

**TABLE 4 SPECIFIED TENSILE LIMITS FOR COLD-DRAWN BARS**  
(Clauses 8.1 and 8.1.1)

DESIGNATION	UP TO 20 mm		OVER 20 mm UP TO 40 mm		OVER 40 mm UP TO 63 mm		OVER 63 mm	
	Tensile Strength, $M_{in}$	Elongation, $M_{in}$ , on Gauge Length $5.65 \sqrt{A}$	Tensile Strength, $M_{in}$	Elongation, $M_{in}$ , on Gauge Length $5.65 \sqrt{A}$	Tensile Strength, $M_{in}$	Elongation, $M_{in}$ , on Gauge Length $5.65 \sqrt{A}$	Tensile Strength, $M_{in}$	Elongation, $M_{in}$ , on Gauge Length $5.65 \sqrt{A}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	N/mm <sup>2</sup>	percent	N/mm <sup>2</sup>	Percent	N/mm <sup>2</sup>	Percent	N/mm <sup>2</sup>	Percent
10C8S10	490	10	450	10	410	13	360	17
14C14S14	540	10	510	11	470	12	430	15
25C12S14	610	8	550	10	510	11	490	13
40C10S18	630	8	590	10	550	11	540	11
11C10S25	490	8	430	11	390	13	360	13
40C15S12	670	7	630	8	610	10	590	11

**TABLE 5 SPECIFIED MECHANICAL PROPERTIES FOR BARS AND FORGINGS IN THE HARDENED AND TEMPERED CONDITION**( *Clauses 8.1 and 8.1.1* )

DESIGNATION	TENSILE STRENGTH	YIELD STRESS, Min ( IF SPECIFIED )	ELONGATION, Min, ON GAUGE LENGTH $5.65\sqrt{A}$	IZOD IMPACT VALUE, Min ( IF SPECI- FIED )	LIMITING RULING SECTION
(1)	(2)	(3)	(4)	(5)	(6)
	N/mm <sup>2</sup>	N/mm <sup>2</sup>	Percent		mm
40C10S18	600-750	380	18	41	60
	700-850	480	17	35	30
40C15S12	600-750	420	18	48	100
	700-850	500	18	48	60
	800-950	560	16	41	30

**11.2 Retest for Mechanical Tests**

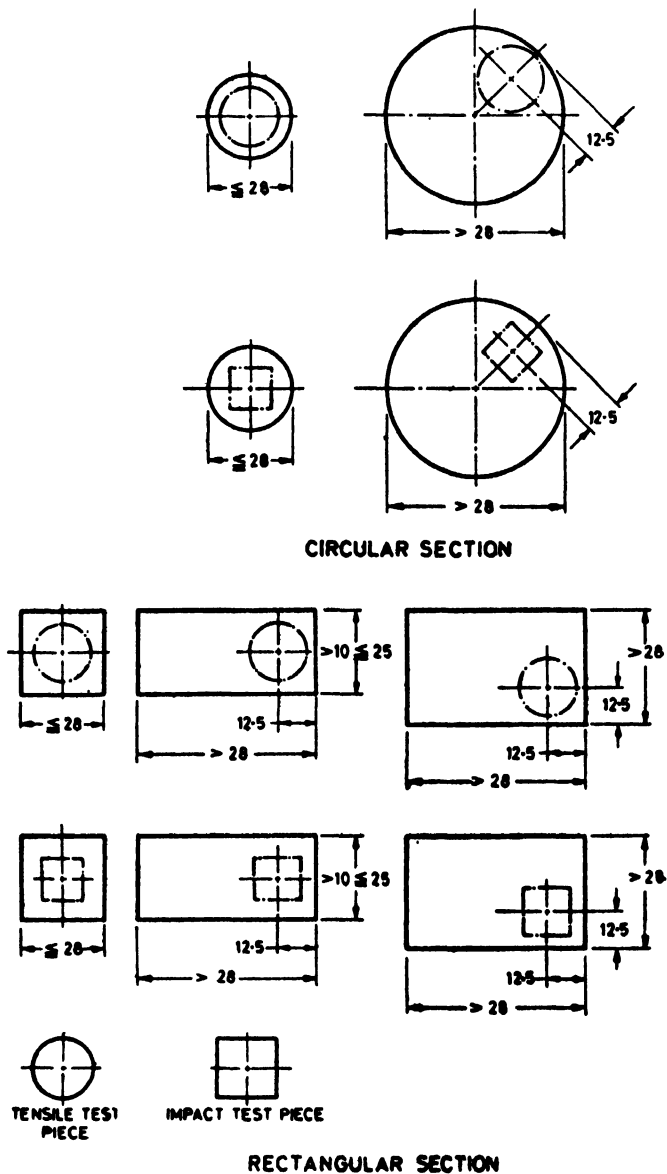
**11.2.1 Hot- and Cold-Worked Material** — If the sample selected under **10.2** and **10.2.1** fails to meet the requirements under **8.1**, two further samples shall be selected from the same lot. Should the two samples satisfy the requirements of this standard, the lot represented shall be accepted. Should either of the samples fail, the material shall be taken as not complying with this standard.

**11.2.2 Heat-Treated Material** — If the sample selected under **10.2** and **10.2.1** fails to meet the requirements under **8.1**, two further samples shall be selected from the same heat-treatment batch. The consignment shall be considered to conform to the requirements if both the additional tests are satisfactory. Should either of the samples fail, the manufacturer shall have the right if he so desires to reheat-treat the product in any suitable manner before two fresh samples are taken for testing. Should the two tests satisfy the requirements of this standard, the lot represented shall be accepted. Should either of the samples fail, the material shall be taken as not complying with this standard.

**12. FINISH**

**12.1** The material may be supplied to any one of the following finishes:

- a) Hot-rolled or forged,
- b) Cold-drawn,
- c) Turned or machined,
- d) Rough ground,
- e) Centreless ground, and
- f) Polished ( rounds only ).



All dimensions in millimetres.

**FIG. 1 LOCATION OF TEST PIECES IN THE PRODUCTS TO BE DELIVERED**

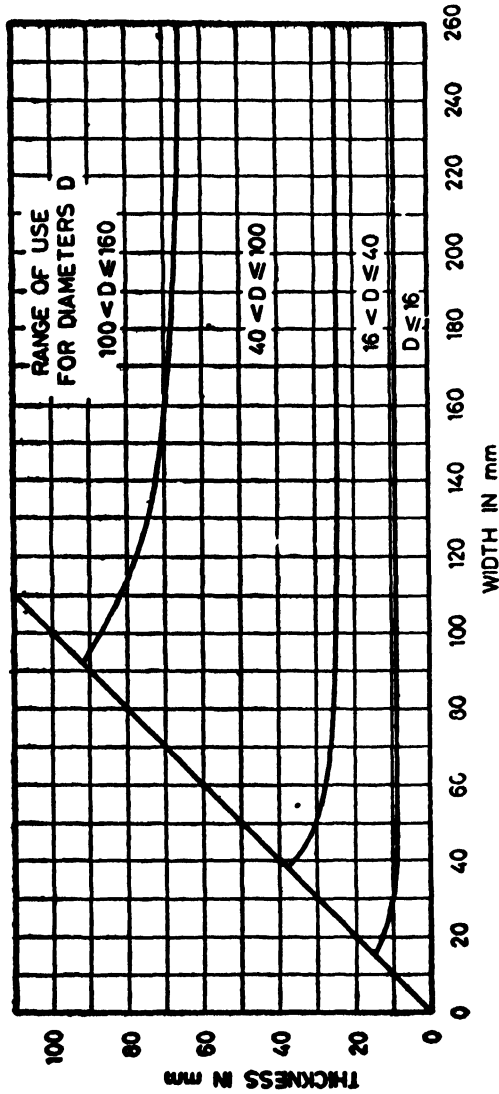


FIG. 2 APPLICABILITY OF THE VALUES, GIVEN IN TABLE 4 FOR ROUND SECTION, TO RECTANGULAR SECTION OF OIL OR WATER-QUENCHED PRODUCTS

**IS : 4431 - 1978**

### **13. MARKING**

**13.1** Colour coding shall be applied in accordance with IS : 2049-1963\*.

**13.2** Each bar, billet or forging shall be marked with cast number or identification mark by which the cast may be traced. In the case of small sized bars and pieces which are securely bundled, the indication may be given on a metal tag attached to each bundle and marked as above.

#### **13.3 BIS Certification Marking**

The product may also be marked with Standard Mark.

**13.3.1** The use of the Standard Mark is governed by the provisions of Bureau of Indian Standards Act, 1986 and the Rules and Regulations made thereunder. The details of conditions under which the licence for the use of Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

## **A P P E N D I X   A**

*( Clause 0.6 )*

### **INFORMATION TO BE SUPPLIED BY THE PURCHASER**

#### **A-1. BASIS FOR ORDER**

**A-1.1** While placing an order for the steels covered by this standard, the purchaser should specify clearly the following:

- a) Grade;
- b) Quality;
- c) Size;
- d) Finish;
- e) Tests required;
- f) Special requirements such as bundling and packing;
- g) Method of manufacture; and
- h) Test report, if required.

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\*Colour code for the identification of wrought steels for general engineering purposes.

**A P P E N D I X B**

( Clause 7.1 )

**RECOMMENDED HEAT-TREATMENT FOR CARBON AND  
CARBON-MANGANESE FREE-CUTTING STEELS**

<i>Steel Designation</i>	<i>Normalizing Temperature °C</i>	<i>Hardening Temperature °C</i>	<i>Quenching Media</i>	<i>Tempering Temperature °C</i>
10C8S10	850 to 880	—	—	—
14C14S14	„	—	—	—
25C12S14	„	—	—	—
40C10S18	„	840 to 870	Oil	—
11C10S25	„	—	—	—
40C15S12	„	840 to 870	Oil	530 to 650

**NOTE** — For case-hardening treatment of 10S11 and 14Mn1S14, see IS : 4432-1967\*.

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\*Specification for case hardening steels.

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5-8-56C, L.N. Gupta Marg, Nampally Station Road, HYDERABAD 500001 320 10 84

E-52, Chitranjan Marg, C- Scheme, JAIPUR 302001 37 38 79

117/418 B, Sarvodaya Nagar, KANPUR 208005 21 68 78

Seth Bhawan, 2nd Floor, Behind Leela Cinema, Naval Kishore Road,  
LUCKNOW 226001 21 89 23

NIT Building, Second Floor, Gokulpat Market, NAGPUR 440010 52 51 71

Patliputra Industrial Estate, PATNA 800013 26 28 08

Institution of Engineers (India) Building, 1332 Shivaji Nagar, PUNE 411005 32 36 35

'Sahajanand House' 3rd Floor, Bhaktinagar Circle, 80 Feet Road,  
RAJKOT 360002 36 85 86

T.C. No. 14/1421, University P. O. Palayam, THIRUVANANTHAPURAM 695034 32 21 04

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\*Sales Office is at 5 Chowringhee Approach, P.O. Princep Street,  
CALCUTTA 700072 27 10 85

†Sales Office is at Novelty Chambers, Grant Road, MUMBAI 400007 309 65 28

‡Sales Office is at 'F' Block, Unity Building, Narashimaraaja Square,  
BANGALORE 560002 222 39 71

**AMENDMENT NO. 1     APRIL 1980**  
**TO**  
**IS : 4431-1978 SPECIFICATION FOR CARBON**  
**AND CARBON-MANGANESE FREE-CUTTING STEEL**  
**( *First Revision* )**

**Corrigenda**

( *Page 7, Table 1, col 7, fifth entry, under 40Cr15Si2, against 'Phosphorus'* ) — Substitute '0.060 Max' for '0.60 Max'.

( *Page 11, Table 5, col 5* ) — Substitute the following for the existing column:

IZOD  
IMPACT  
VALUE,  
*Min*  
( IF SPECI-  
FIED )

(5)

J ( kg-m )

41 ( 4.1 )

35 ( 3.5 )

48 ( 4.8 )

48 ( 4.8 )

41 ( 4.1 )

AMENDMENT NO. 2    MARCH 1983  
TO  
IS:4431-1978 SPECIFICATION FOR CARBON AND CARBON-  
MANGANESE FREE-CUTTING STEEL

*(First Revision)*

Alteration

(Page 6, clause 6.1) - Substitute the following for the existing clause:

'6.1 The ladle analysis of steel shall be as given in Table 1. The analysis of steel shall be carried out either by the method specified in IS:228 Methods of chemical analysis of steels and its relevant parts or any other established instrumental/chemical method. In case of dispute the procedure given in IS:228 Methods of chemical analysis of steels and its relevant parts shall be referee method. However, where the method is not given in IS:228 Methods of chemical analysis of steels and its relevant parts, the referee method shall be agreed to between the purchaser and the manufacturer.'

(SMDC 19)